CALIBRATION OF THE INFRARED CAMERA

PROCEDURE ID: YMP-LBNL-TIP/TT5.0 | REV. 1, MOD. 0 | EFFECTIVE: 01/21/2000

1. PURPOSE

This Technical Implementation Procedure (TIP) describes a method to calibrate Inframetrics Thermacam (SN 8954) and similar cameras over a specific range of temperatures in the laboratory or field for the Yucca Mountain Site Characterization Project (YMP) at the Lawrence Berkeley National Laboratory (LBNL).

2. SCOPE

This procedure applies to all LBNL personnel (or contractor personnel following LBNL procedures) involved in calibration of the Inframetrics Thermacam (SN 8954) or similar camera over a specific range of temperatures for the YMP that are subject to the Quality Assurance Requirements and Description (QARD), DOE/RW-0333P. Prior to conducting work described in Section 3.0 of this procedure, personnel performing calibrations require training to this procedure.

For all technical activities, data collected using this procedure and any equipment calibrations or recalibrations that may be required shall be in accordance with this TIP and in full compliance with YMP Administrative Procedure (YAP)-12.3Q, *Control of Measuring and Test Equipment and Calibration Standards.* Documentation resulting from actions taken under this TIP shall be recorded in Scientific Notebooks as described in the Office of Civilian Radioactive Waste Management (OCRWM) Administrative Procedure (AP)-SIII.1Q, *Scientific Notebooks*. Measurements and calibrations of other equipment not specifically mentioned herein shall be in full compliance with YAP-12.3Q. Electronic data maintenance, controls and transfers shall comply with YMP-LBNL-Quality Implementing Procedure (QIP)-SV.0, *Control of the Electronic Management of Data.*

If this procedure cannot be implemented as written, YMP-LBNL personnel shall notify the responsible Principal Investigator (PI) or designee. If it is determined that a portion of the work cannot be accomplished as described in this TIP, or would produce undesirable results, that portion of the work shall be stopped and not resumed until this procedure is modified per YMP-LBNL-QIP-5.2, *Preparing Development Plans & Quality /Technical Implementing Procedures*.

If the responsible PI or designee determines that a modification or a revision to the TIP would cause an unreasonable delay in proceeding with the task, then an expedited change to the procedure, including documentation of deviation from

the approved procedure, can be made according to YMP-LBNL-QIP-5.2. Such changes are subject to review, usually after the task has proceeded, and thus work performed under TIPs with expedited changes is done at risk of future invalidation.

Employees may use a controlled electronic or hard copy of this procedure; however, employees are responsible for assuring that the correct revision of this procedure is used. When this procedure becomes obsolete or superseded, it shall be destroyed or marked "superseded" to ensure that this document is not used to perform work.

3. PROCEDURE

The infrared camera (Thermacam) is calibrated by plotting the indicated temperature against the accurately known temperature of a blackbody. The temperature of the blackbody is controlled by immersion in a controlled temperature bath (in the multi-point procedure), or the environment (in the single-point procedure). Two procedures are described below; (1) a multi-point procedure useful for generating a calibration curve over a temperature range of interest, and (2) a single point procedure useful for field verification of infrared camera performance under field conditions. Neither procedure is valid under intense lighting conditions where surface heating may occur such as on a blackbody under intense sunlight, nor near infrared (IR) energy sources where reflected IR energy may alter measurements.

3.1 Standard to be Used

The standard against which the infrared camera is calibrated to is a thermometer calibrated by a qualified supplier according to YAP-12.3Q. The readability (most precise clearly readable temperature, generally a fraction of the smallest division labeled on the thermometer) of the thermometer will be used to determine the accuracy of infrared camera calibration.

3.2 Multi-Point Method for Infrared Camera Calibration

3.2.1 Use a "blackbody" made out of metal tubing at least 6-times as long as the tubing diameter, unless a coating is used in which case a shorter piece of tubing or other object may be used. Seal one end of the tubing. If a coating is used, it must be an accepted emmissivity paint such as Emmissivity Paint EP10 Flame Proof Coating SP-102 Flat Black (Wahl Instruments, Inc., Culver City, CA 90231) used as per manufacturers instructions. The blackbody opening shall be large enough to get a temperature reading in the camera.

3.2.2 Ambient laboratory temperature shall be recorded in the scientific notebook.

3.2.3 Support the blackbody so that it is almost entirely submerged in a controlled temperature bath containing water or an appropriate liquid for the temperature range desired, in which a thermometer properly calibrated is inserted near the blackbody (See Attachment 1). Control the temperature of the surroundings appropriately, so that it remains stable over the duration of calibration and is as similar as possible to the conditions in which the measurements will be made. Both support and temperature control may be accomplished simultaneously by boring a hole in an appropriately sized piece of insulating material, and inserting the blackbody a small distance into the hole. This assembly can be placed over the controlled temperature bath with the open end of the blackbody open upwards (See Attachment 1).

3.2.4 Position the camera such that its axis is aligned with the axis of the blackbody at a distance approximately equal to the distance the camera will be from objects to be measured.

3.2.5 Set the time indicated by the infrared camera to clock time or note and record in a scientific notebook the difference between the two times. Clock time and bath temperature data shall be collected and recorded in a scientific notebook when data is collected using a video system.

3.2.6 Adjust the temperature in the controlled temperature bath as necessary.

3.2.7 Temperature data from the camera shall be collected and evaluated during calibration using the same methods and equipment as during laboratory or field investigation. The method selected is at the discretion of the investigator and shall be recorded in the scientific notebook. If laboratory or field data are to be captured on RAM cards or recorded from camera readout, calibration data shall be collected on RAM cards or recorded in the scientific notebook and evaluated with the same technique and equipment used to evaluate the laboratory or field data. If the laboratory or field data are to be captured on video tape in "Tgram" format, calibration data shall be collected on video tape in "Tgram" format with the same technique and equipment used to evaluate the laboratory or field data. If it is desired to use both data collection methods (RAM cards and "Tgram" output), data from both methods must be collected and the calibration curves for both methods must be demonstrated to be the same. Data output in “Tgram” format and recorded to tape or data captured on RAM cards

shall be retrieved through an appropriate data acquisition system such as the Inframetrics acquisition board using appropriate software such as ThermaGRAM95 version 1.30 (Thermokinetics Systems Ltd., Mt. Pleasant House, Mt. Pleasant, Cambridge, CB3 ORN. UK) and data in units retrieved by the data acquisition system such as Instrument Units (IU) shall be compared and plotted with the recorded temperatures to generate a calibration curve. The calibration curve can then be used to calibrate data sets by hand or in user selected software such as EXCEL. Software management and control will be performed according to AP-SI.1Q *Software Management*.

3.3 Single-Point Method for Infrared Camera Calibration

A one-point calibration may be performed when expected temperatures are within a narrow range of the calibration temperature. This calibration is performed using a suitable blackbody such as a black velvet thermometer case and calibrated thermometer. The infrared camera is aimed at the blackbody, and the camera indicated temperature is compared to the temperature indicated by the calibrated thermometer. These temperatures are recorded in a scientific notebook as well as the range of expected temperatures for use.

3.4 Documentation

The Staff Member shall document the following information in the Scientific Notebook or the M&TE Calibration Documentation Form (Attachment 2) :

a) The unique identification and description or type of the M&TE calibrated

b) Date calibrated

c) Calibration data, results of the calibration, and statement of acceptability

d) Re-calibration due date or calibration interval / frequency

e) Procedure (including revision level) used to calibrate the M&TE

f) Identification of and traceability to the calibration standards used for the calibration

g) As-found condition of the M&TE, as appropriate

h) Specified range and tolerances and whether the M&TE met those

tolerances

i) Personnel performing calibrations

j) Reference to actions taken with out-of-calibration or non conforming M&TE, including evaluation results, as appropriate

k) Nonretrievability status (NR or R)

The M&TE Calibration Documentation Form (Attachment 2) may be used to document the above. If used, it shall be filed in the scientific notebook. If this form is not used, the

3.4.1 Controls for nonconforming or out-of-tolerance conditions:

Nonconforming or out-of-tolerance equipment shall be segregated or tagged with an Out-of-Service tag in accordance with YAP-12.3Q and not be used. Recalibration shall be attempted to remedy the nonconformance. If this is ineffective, the nonconforming equipment shall be replaced if possible. If replacement is impossible or the replacement timeframe is such that sample degradation will occur rendering samples useless, nonconforming equipment may be used with notification of the PI and an evaluation of the effects of using such equipment on the data is performed and documented on the M&TE Out of Calibration Report (OCR) as described in YAP-12.3Q. The OCR shall be filed in the scientific notebook. If it is determined that the data is impacted, a Nonconformance Report (NCR) shall be initiated in accordance with YAP-15.1Q.

3.4.2 Recalibration when updates to software affects calibration:

The infrared camera shall be recalibrated following changes to its internal software. If a change in external software used to evaluate infrared camera data is made, recalibration may be necessary according to Section 3.2.7.

3.4.3 Staff Members shall document each usage of the equipment on the M&TE Standard Usage Log or in a scientific notebook as described in YAP-12.3Q and file the form in the scientific notebook. If the M&TE Standard Usage Log is not used, information required on this form shall be recorded in the Scientific Notebook.

3.5 Consideration of manufacturer's recommendations for storage and handling:

The Thermacam is a piece of electronic and optical equipment and as such shall not be handled in a manner which incurs breakage (i.e. dropping). The camera shall not be used outside at temperatures below –20 C nor above 50 C and shall be stored indoors in a dry environment.

3.6 Range and Tolerances

The camera works in various ranges, thus the range of interest must be selected prior to calibration. For field work, the range from 0 to 70 C is of primary interest. Laboratory investigations may require the range to be from 70 to 120 C. The calibration range must be specified and recorded on the M&TE Calibration Documentation Form or in a scientific notebook. The tolerance shall be determined from the calibration curve using the r^2 value.

3.7 Calibration frequency.

The Thermacam shall be calibrated annually. Operational checks, with at least one data point shall be performed prior to and following each use. If the difference between the expected and measured temperature is greater than 5 C, the Thermacam shall be recalibrated. If this is not possible due to its usage in the field, the difference between the expected and measured temperatures shall be performed regularly over the course of making measurements to establish a baseline for data evaluation.

3.8 Calibration Sticker

A calibration sticker shall be affixed to the to the camera case stating the person performing the calibration, unique identifier of the camera (manufacturer, model, serial number), date of the calibration, next calibration date, range and tolerances.

4. RECORDS

4.1 Lifetime

Records generated as a result of this TIP are entries in scientific notebooks or attachments to such notebooks.

4.2 Non-Permanent

None

4.3 Controlled Documents

Technical Implementing Procedure

4.4 Records Center Documents

Records associated with this procedure shall be submitted to the Records Coordinator for transmittal to the Records Processing Center (RPC) in accordance with AP-17.1Q, *Record Source Responsibility for Inclusionary Records*.

5. RESPONSIBILITIES

5.1 Staff Members involved in these activities are responsible for following this procedure and turning over related documentation to the Records Coordinator for submittal to the RPC in accordance with AP-17.1Q. Related data shall be turned over to Technical Data Coordinator for submittal to the YMP Technical Data Management System (TDMS) in accordance with AP-SIII.3Q, *Submittal and Incorporation of Data to the Technical Data Management System*.

6. ACRONYMS AND DEFINITIONS

6.1 Acronyms

AP	OCRWM Administrative Procedure
IR	infrared
IU	Instrument Units
LBNL	Lawrence Berkeley National Laboratory
M&TE	Measuring and Test Equipment
NCR	Nonconformance Report
OCRWM	Office of Civilian Radioactive Waste Management
OCR	Out of Calibration Report

PI	Principal Investigator
QIP	Quality Implementing Procedure
RAM	Random Access Memory
RPC	Records Processing Center
TIP	Technical Implementing Procedure
TDMS	Technical Data Management System
YAP	YMP Administrative Procedure
YMP	Yucca Mountain Site Characterization Project

6.2 Definitions

Calibration: Comparison of a measurement standard or instrument of known accuracy with another standard or instrument to detect, correlate, report, or eliminate by adjustment any variation in the accuracy on the instrument of equipment being compared.

Calibration curve: A plot of values indicated by the instrument against known accurate values.

Staff Member: Any scientist, engineer, research or technical associate, technician, or student research assistant performing quality-affecting work for YMP-LBNL.

Technical Implementing Procedure: Each TIP describes YMP-LBNL technical tasks that (1) are repetitive, (2) are standardized, and (3) can return different results if deviation from the sequence of steps occur.

7. REFERENCES

AP-17.1Q, *Record Source Responsibility for Inclusionary Records*

AP-SI.1Q, *Software Management*

AP-SIII.1Q, *Scientific Notebooks*

AP-SIII.3Q, *Submittal and Incorporation of Data to the Technical Data Management System*

DOE/RW-0333P, *Quality Assurance Requirements and Description (QARD)*

YAP-12.3Q, *Control of Measuring and Test Equipment and Calibration Standards*

YMP-LBNL-QIP-5.2, *Preparing Development Plans & Quality/Technical Implementing Procedures*

YMP-LBNL-QIP-SV.0, *Control of the Electronic Management of Data*

8. ATTACHMENTS

Attachment 1. Diagram of calibration setup, Multi-Point Procedure.

Attachment 2. M&TE Calibration Documentation Form

9. REVISION HISTORY

09/30/98 – Revision 0, Modification 0:

This is the initial issue of this procedure. Derivative of a scientific notebook procedure/methodology prepared by T.J. Kneafsey on 07/16/97, 07/21/97, and 07/22/98 as part of the scientific investigation presented in the Scientific Notebook YMP-LBNL-TJK-1contd.

01/21/2000 – Revision 1, Modification 0:

Revised procedure to meet the YAP-12.3Q requirements, and incorporated references to current APs, YAPs, and QIPs. Deleted responsibilities for staff members not directly responsible for implementing this procedure.

10. APPROVAL

Signature on file

Preparer: Timothy J. Kneafsey — Date:

Signature on file

Technical Review: Paul Cook — Date:

Signature on file

Technical Review: Peter Persoff — Date:

Signature on file

EA Review: Nancy Aden-Gleason — Date:

Signature on file

OQA Concurrence: Stephen D. Harris — Date:

Signature on file

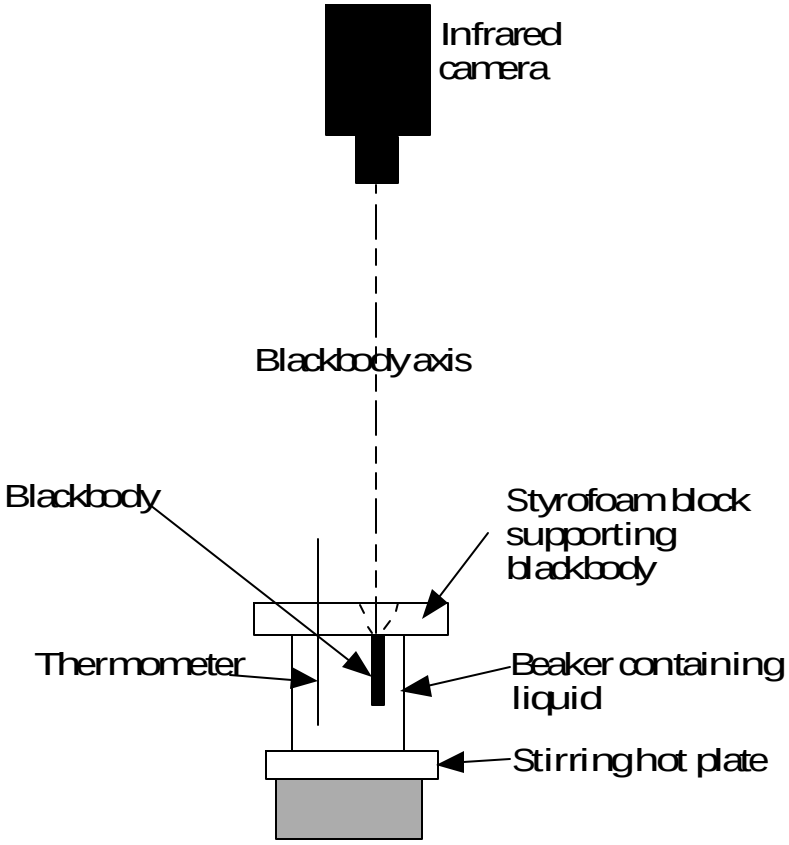
Principal Investigator: Karsten Pruess — Date:

Signature on file

Project Manager: Gudmundur Bodvarsson — Date:

DIAGRAM OF CALIBRATION SETUP
ATTACHMENT 1

PROCEDURE ID: YMP-LBNL-TIP/TT5.0	REV. 1, MOD. 0	EFFECTIVE: 01/21/00



Attachment 1. Diagram of calibration setup, Multi-Point Procedure.

Measuring and Test Equipment (M&TE) Calibration Documentation Form

<table>
<tr><td>a) M&TE Description</td><td>b) M&TE Unique Identification</td><td>c) Calibration Date and Time (if applicable)</td></tr>
<tr><td colspan="2">d) Person Performing Calibrations</td><td>e) M&TE Condition (As-Found)
Working _____

Not Working _____</td></tr>
<tr><td colspan="2">f) Calibration Procedure (including revision level)</td><td>g) Calibration Standards Used</td></tr>
<tr><td colspan="2">h) Location of Calibration Data

YMP-LBNL-_____
Page(s)</td><td>i) Location of Calibration Results

YMP-LBNL-_____
Page(s)</td></tr>
<tr><td colspan="3">j) Statement of Acceptability including Acceptability of Range and Tolerances
Range Acceptable Yes _____, No _____
Tolerance Acceptable Yes _____, No _____
Calibration Acceptable Yes _____, No _____
Comment:</td></tr>
<tr><td colspan="3">k) Specified Range and Tolerances</td></tr>
<tr><td colspan="2">l) Re-calibration due date or calibration interval/frequency</td><td>m) Reference to actions taken with out-of-calibration or non conforming M&TE, including evaluation results, as appropriate

YMP-LBNL-_____
Page(s)</td></tr>
<tr><td colspan="3">n) Comments</td></tr>
</table>

Signature Date